

TISA Ed4 GEO LW Development Update

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CERES Science Team Meeting
October 29-31, 2013, Scripps Institute, La Jolla



Outline

- Current GEO LW flux Status
- Review previous Ed4 LW improvement effort
- New Ed4 GEO LW Flux Algorithm
- Preliminary Results
- Summary



Edition3 GEO LW NB->BB Flux Algorithm

- IR => Nadir NB flux

$$F_{NB} = 1.97 \pi L_{WN}(\theta) / \gamma(\theta)$$

$$\gamma(\theta) = \begin{cases} 1 & \theta \leq 11.7 \\ 1.000665 + 0.0324721 \ln(\cos\theta) & \theta > 11.7 \end{cases}$$

Limb darkening function

- NB flux => BB flux (OLR)

$$OLR_{BB} = a_0 + a_1 F_{NB} + a_2 F_{NB}^2 + a_3 F_{NB} \ln(RH)$$

Column Relative Humidity

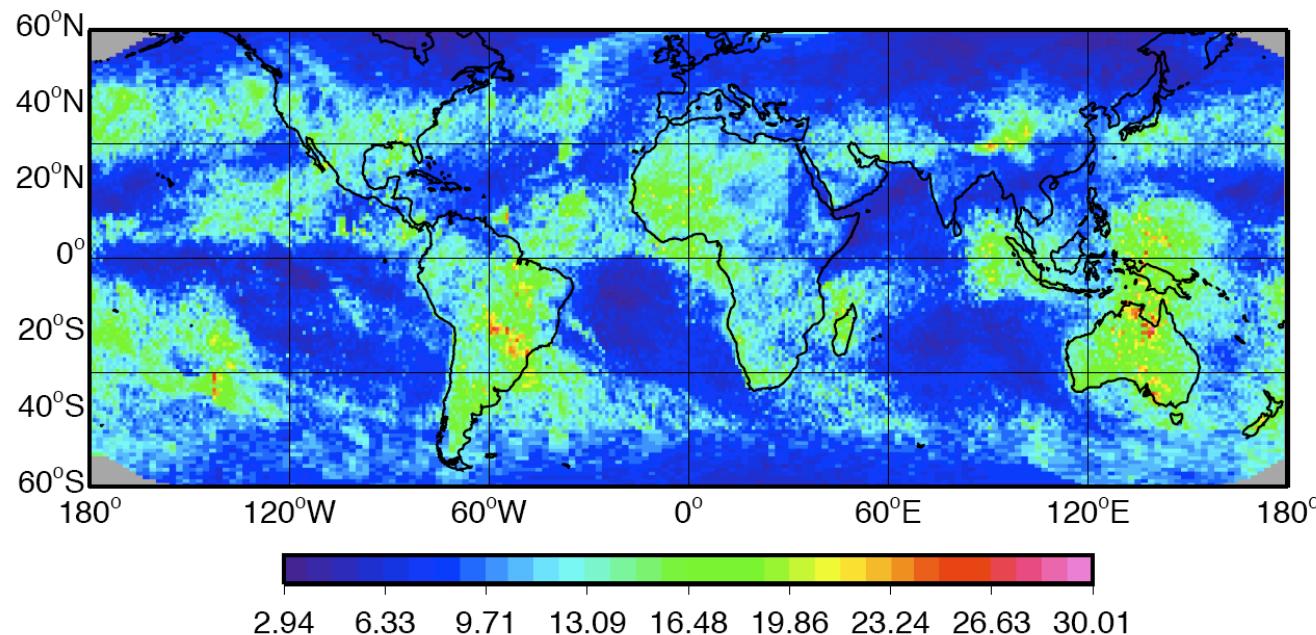
NB flux

a_0, a_1, a_2, a_3 *Coefficients for ocean and land separately*

Minnis, Young and Harrison, J. of Cli., 1991



SYN1deg Edition3a GEO NB-BB Flux Matched GEO vs. Terra, January 2006



Average regional RMS: 8.39 W/m²

GEO LW and CERES-Terra Matched within 1.5 hours LW fluxes



MODIS 6.7 μ m WV channel

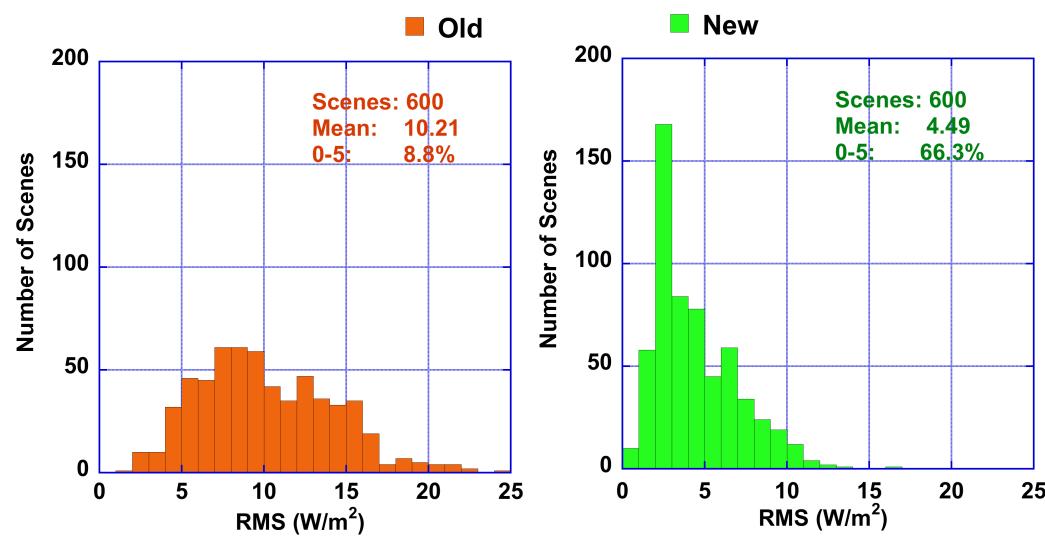
- Demonstrated the advantage of adding 6.72 μ m Water Vapor Channel based on SSF-Ed4 MODIS radiance and CERES flux
- Scene types:
 - **Ocean/land (6)**: Ocean, Forests, Savannas, Grass-Crop, Dark and Bright Deserts.
 - **Day/Night (2) , Clear/cloud (2), Precipitable Water (4)**
 - **Viewing Zenith Angle (7)**: 0°-70°, every 10°

Total: 672 scene types

Conclusion: >50% RMS reduction using both IR & WV vs. IR-Only



NB Rad \rightarrow BB Flux New Ed4 2-ch vs. Ed3 IR-only



RMS

Based on SSF-Ed4 April, 2000



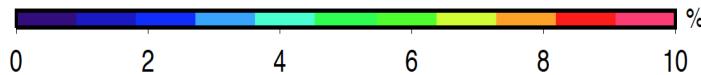
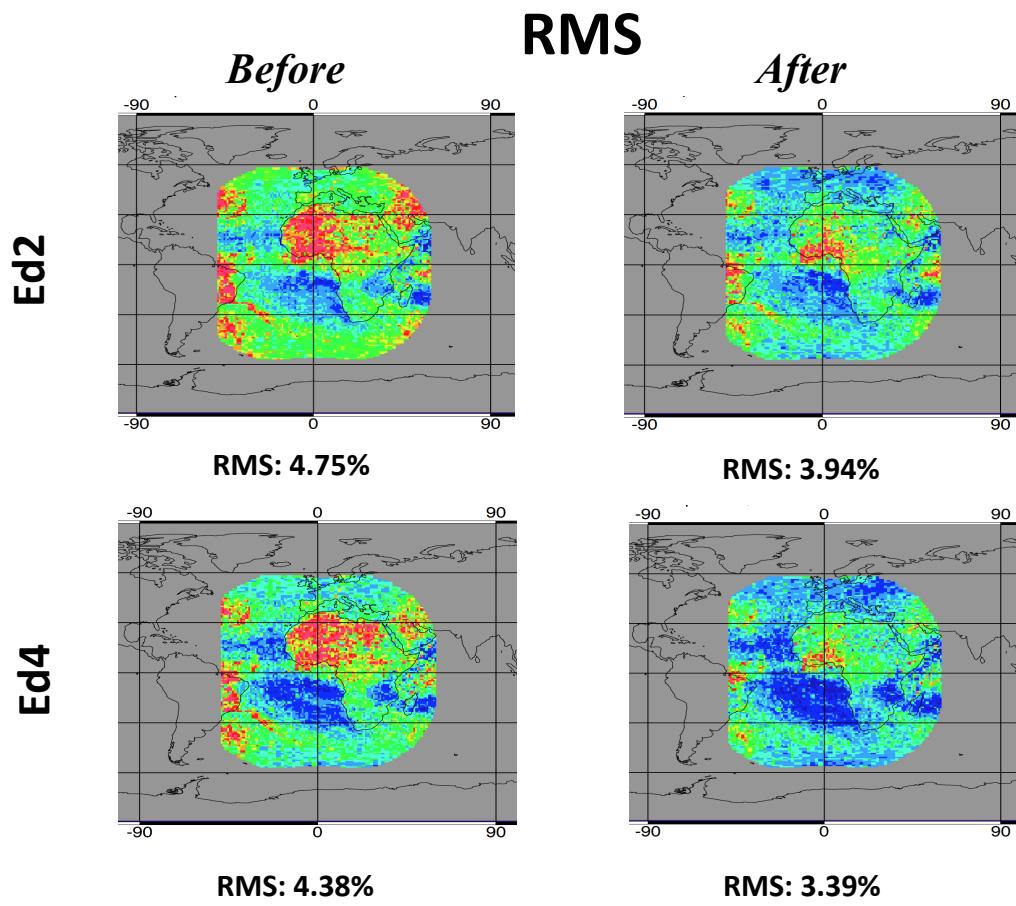
First method: 2-Step LW Conversion

- Step 1: NB Radiance -> BB Radiance
 - Derive regression coefficients based on MODIS narrow-band (11.03 μ m and 6.72 μ m) and CERES broad-band radiance binned by: Surface type(6), PW(3), Tdiff(5), VZA(7), Cloud(5), IR Emissivity(6)
- Step 2: BB Radiance -> BB Flux
 - Apply above coefficients to GEO narrow-bands to obtain broad-band radiance.
 - Use Ed3 LW ADM to convert above GEO derived BB Radiance to Flux.
- Normalized to CERES

Summary: 2-Step shows great improvement over large VZA area. Desert improves moderately. Ocean shows little or no improvement. Normalization reduces RMS moderately.



Preliminary Results: Normalization April, 2010 LW Flux : GGEO-CERES RMS



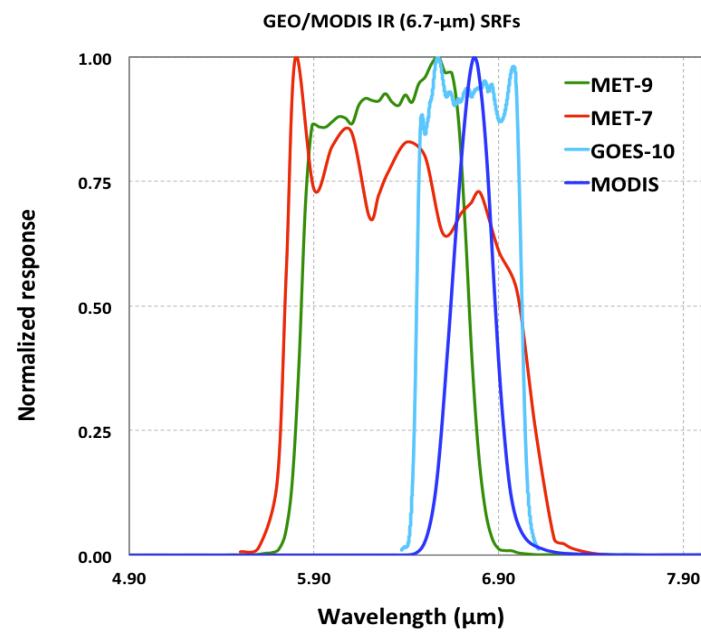
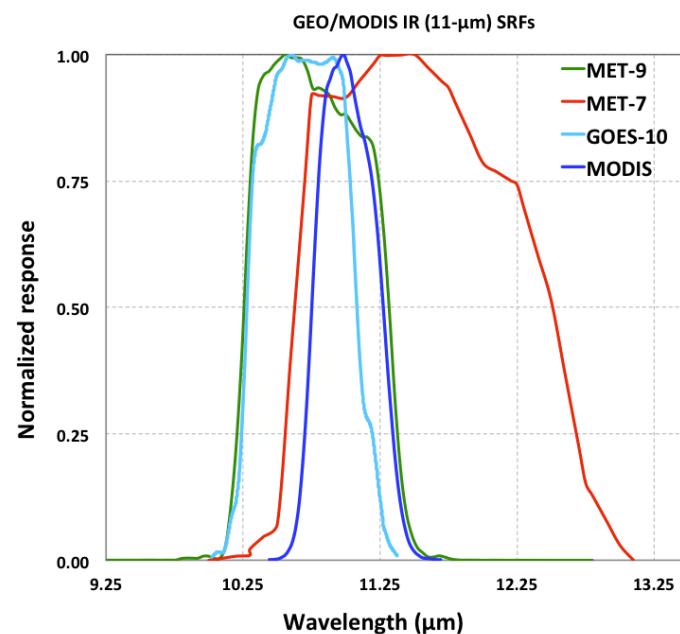
New Ed4 GGEO LW Flux Algorithm (1-Step)

- 1-Step
 - Derive regression coefficients from MODIS narrow-band (11.03 μ m and 6.72 μ m) and CERES broad-band flux based on: Surface type(6), PW(4), VZA(31), Rad(6).
 - Apply above coefficients to convert GEO radiance to BB flux.
- Normalized to CERES
 - Regress regional LW flux GEO and CERES flux pairs coincident within 1.5 hours over the month and over 5x5 regions centered at the given region
- Validate against GERB 1-hourly data, January, 2010



Adjustment of GEO Radiance to MODIS-like Rad

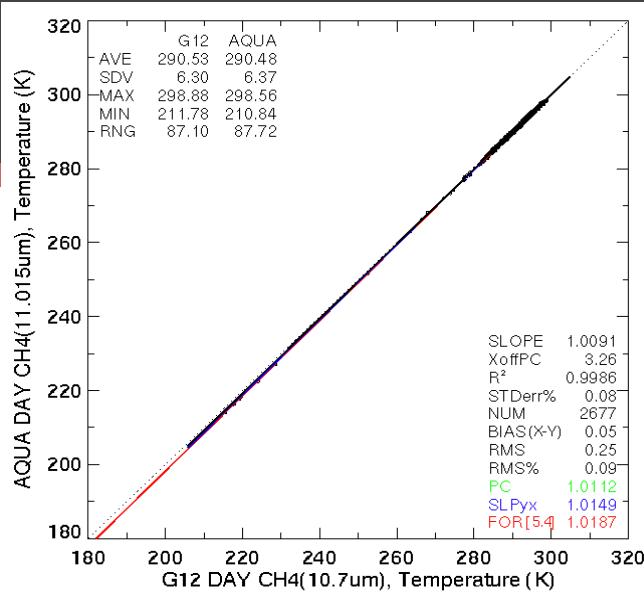
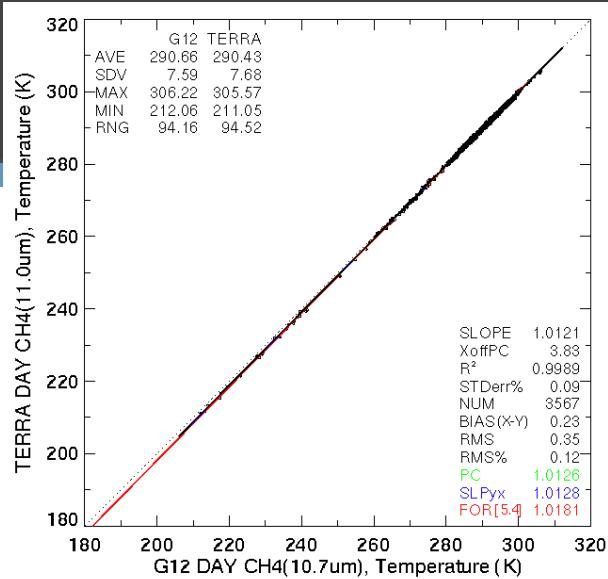
MODIS vs. GEO SRF



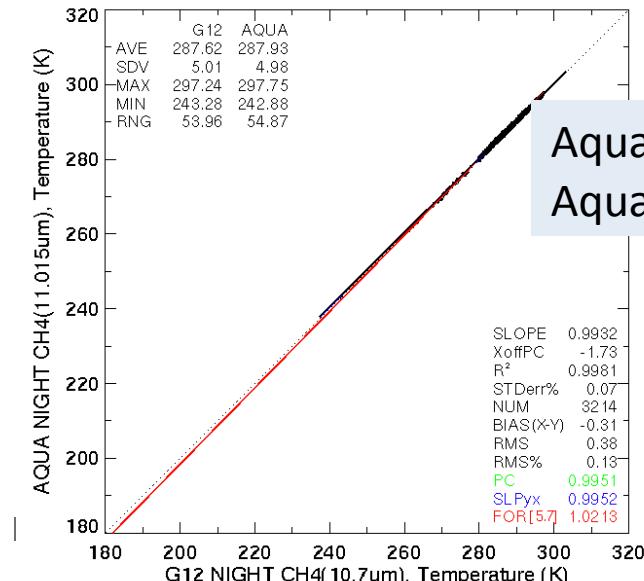
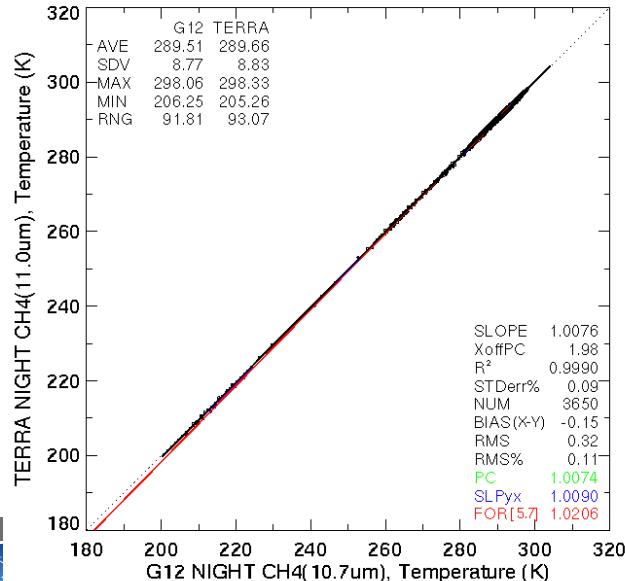
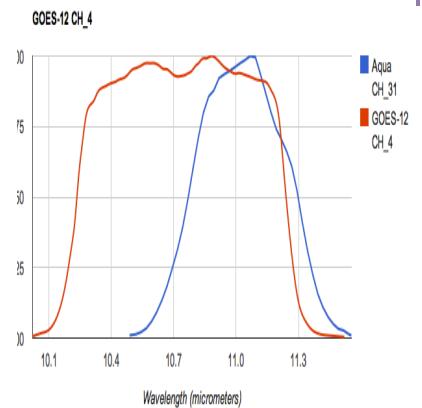
The coefficients converting NB to BB are based on MODIS Rad and CERES flux,
The adjustment is needed when apply these coefficients to GEO Rad -> Flux.



Adjustment of GEO IR



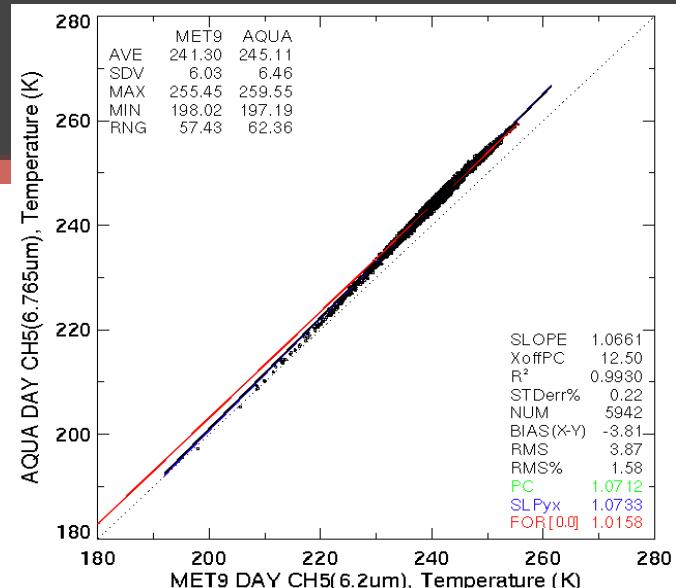
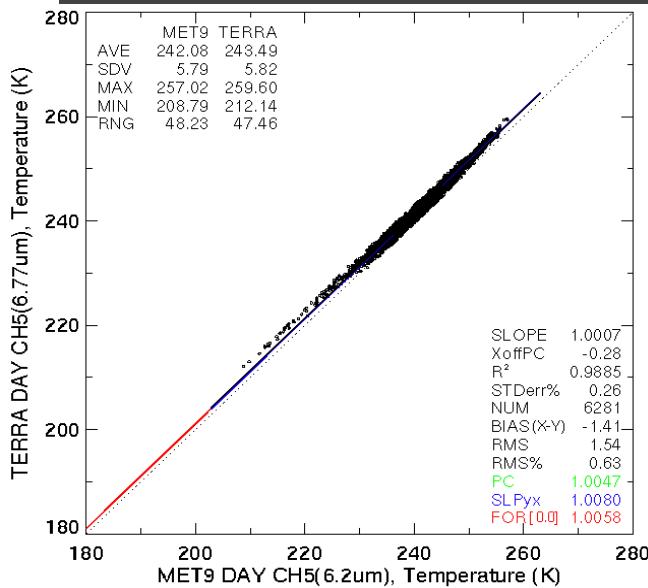
GOES-12



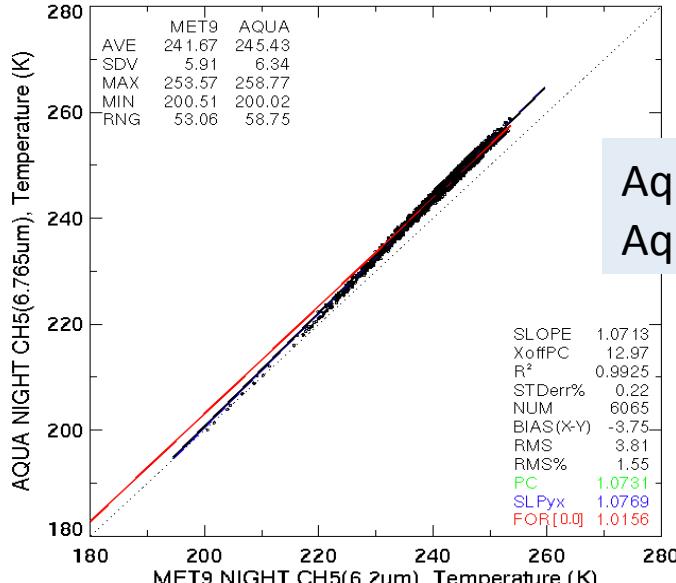
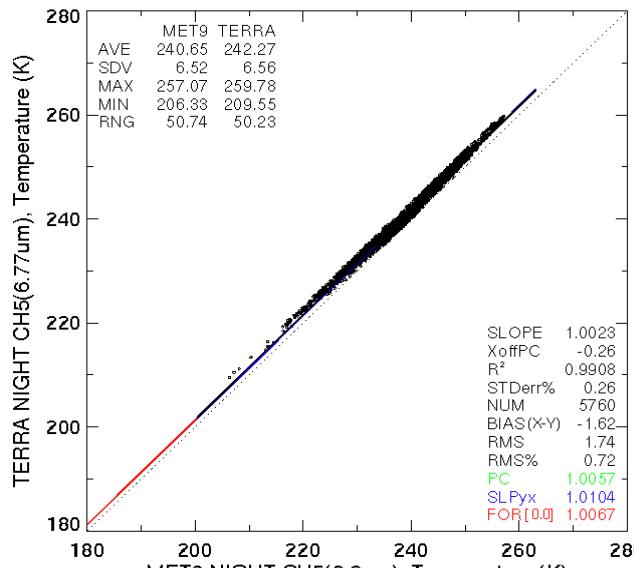
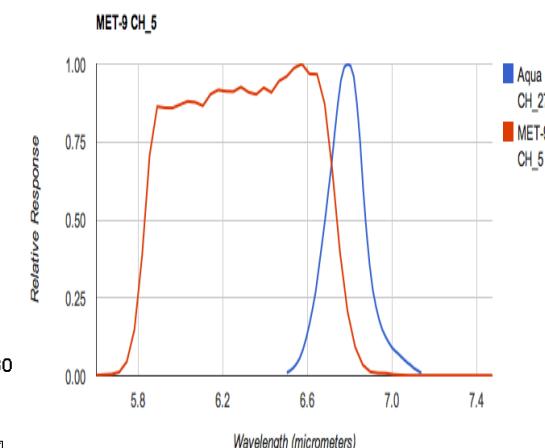
$AquaD = G12 * 1.0187 - 5.4$
 $AquaN = G12 * 1.0213 - 5.7$



Adjustment of GEO WV



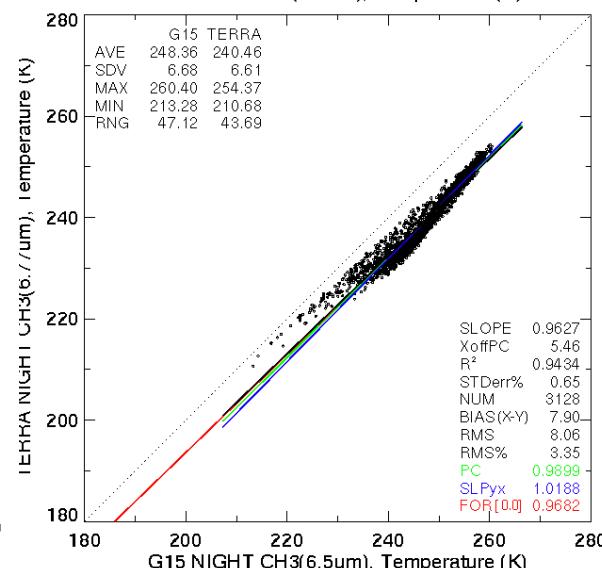
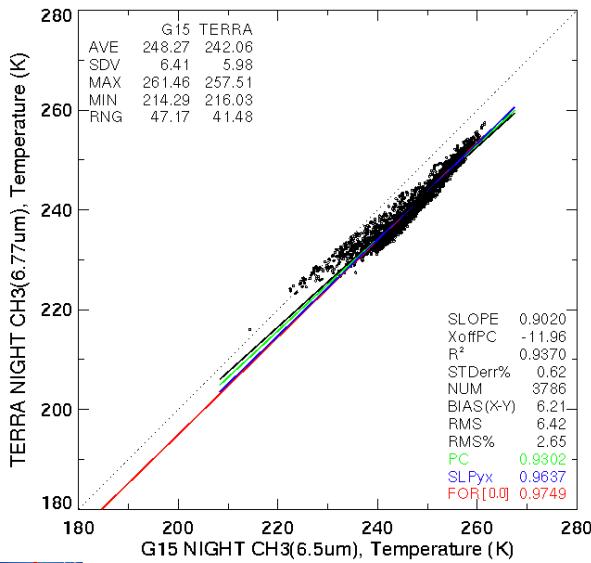
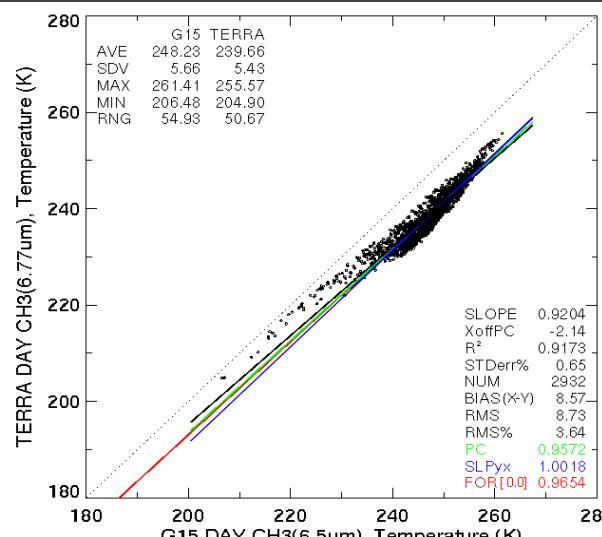
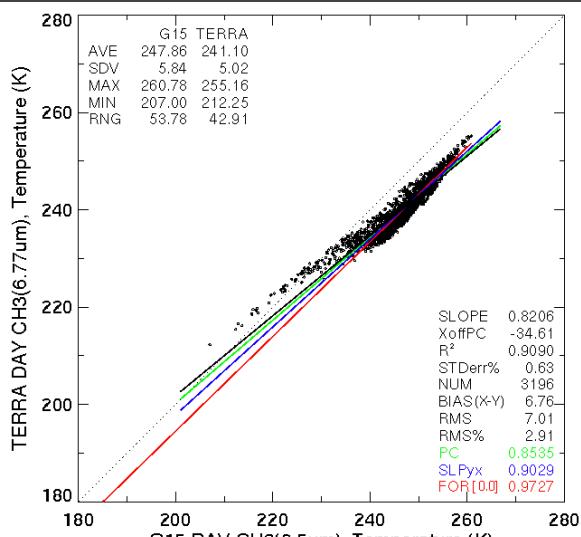
Meteosat-9



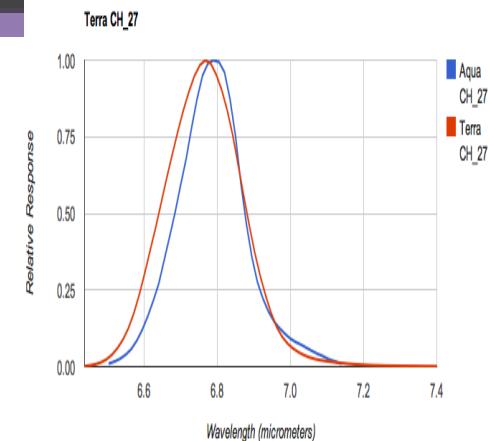
AquaD= Met9*1.0712-12.50
AquaN = G12*1.0731 – 12.97



Terra MODIS WV Problem



Terra/GOES-15



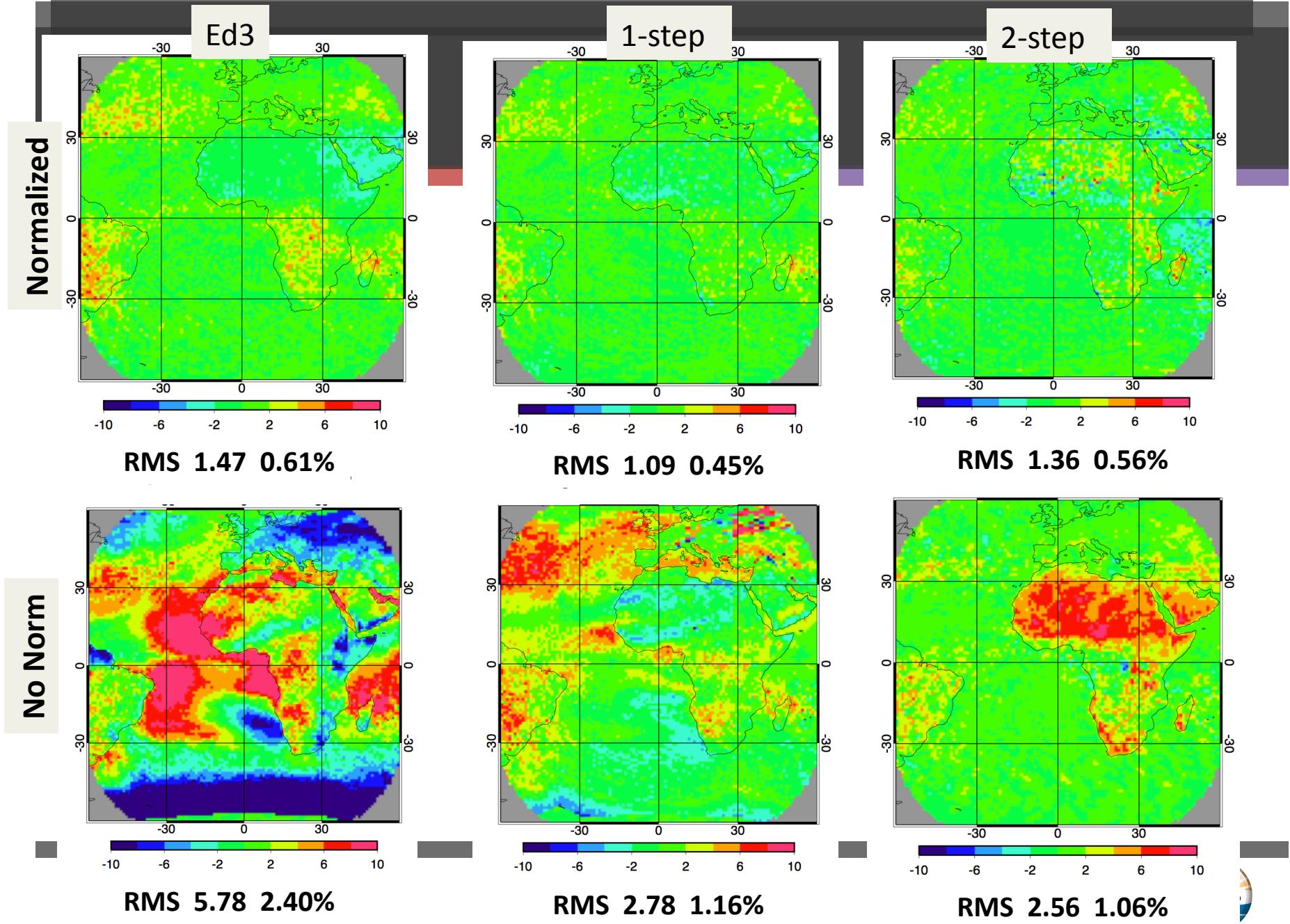
**Terra-MODIS WV has electronic cross talk and should not be used
Use Aqua MODIS Only**

Sun J. et al, 2011, SPIE

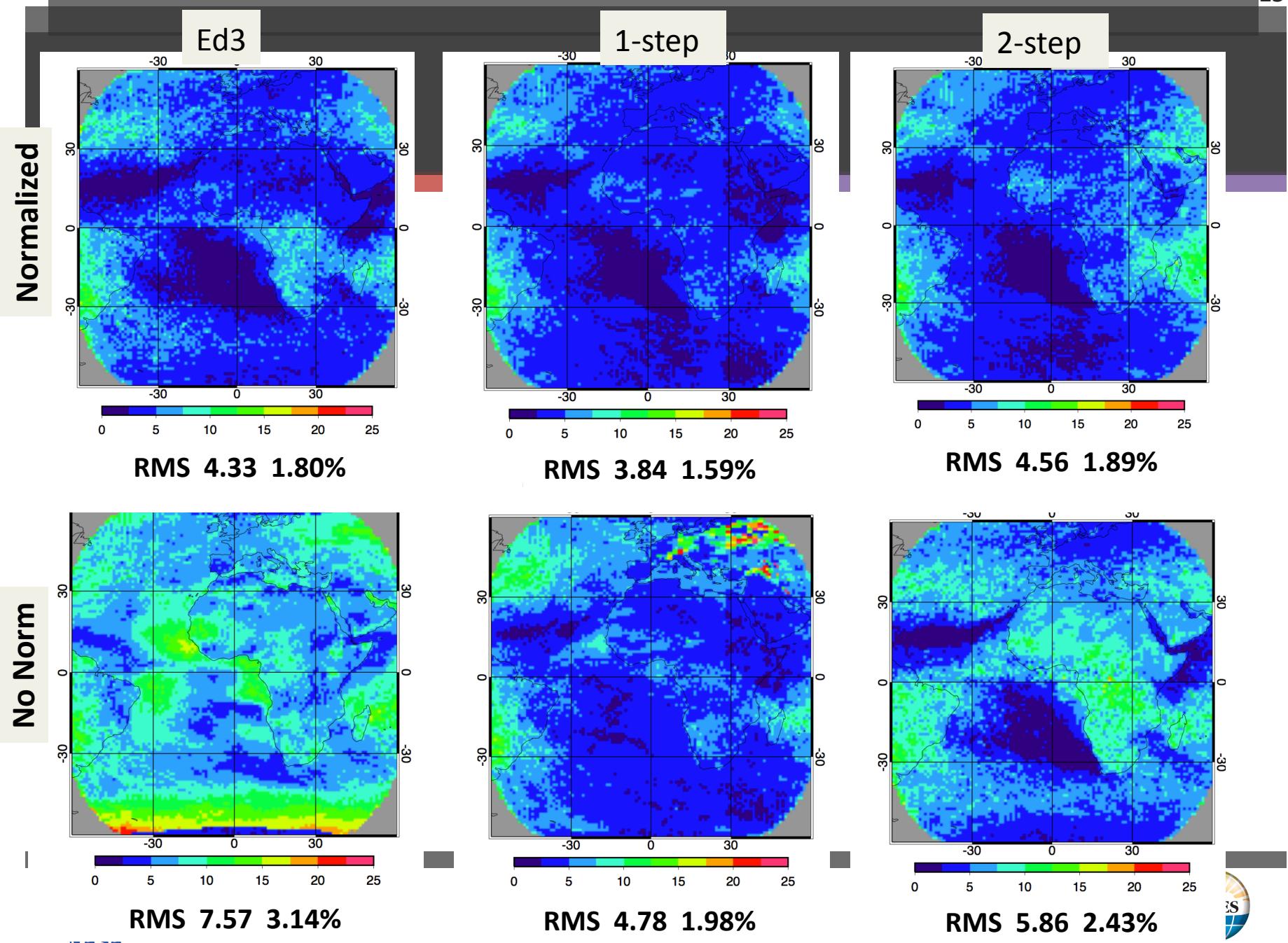


Results: Ed4 Flux Monthly Mean

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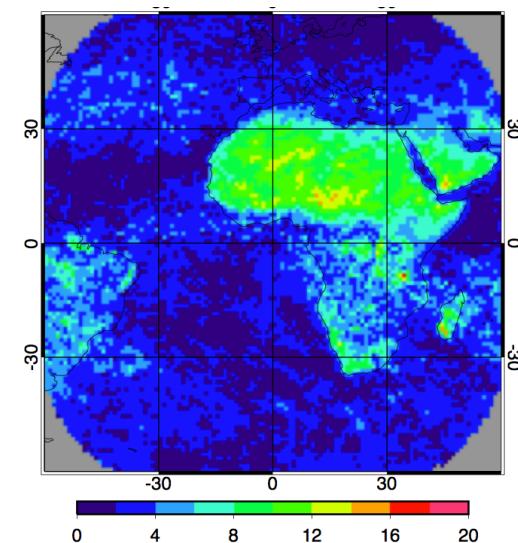
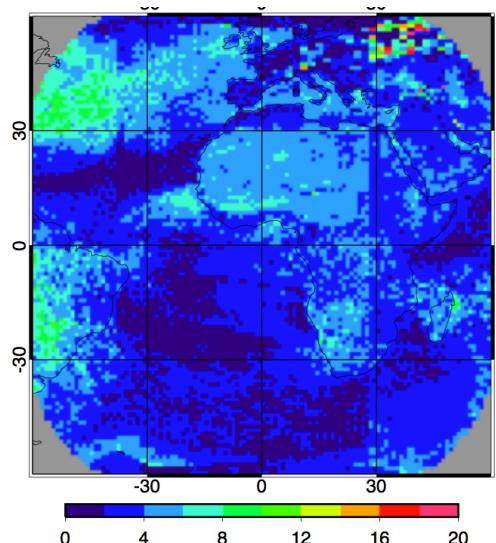
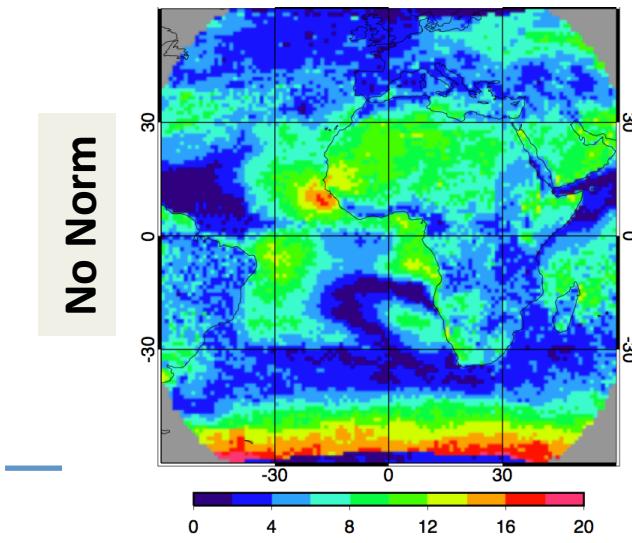
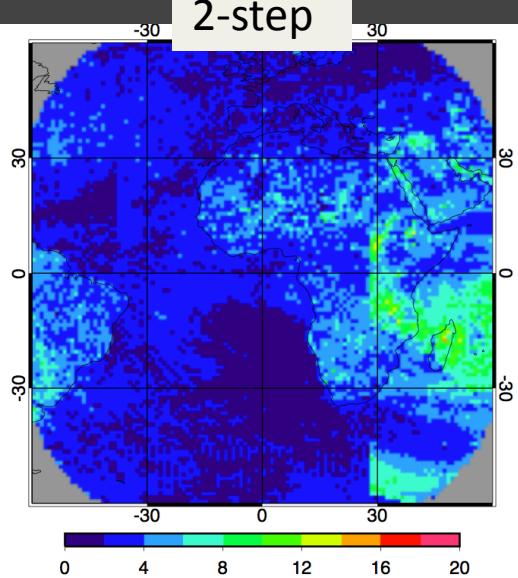
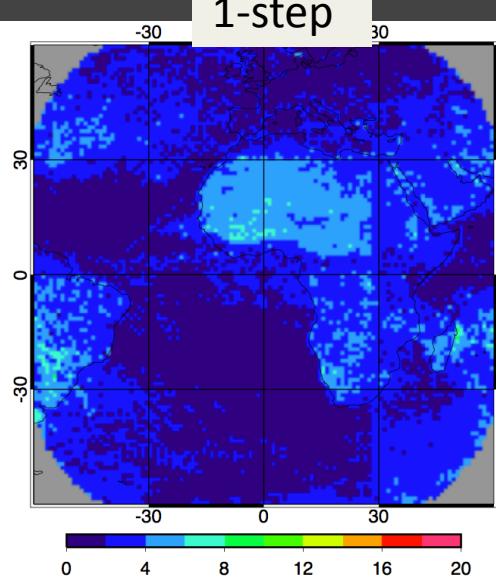
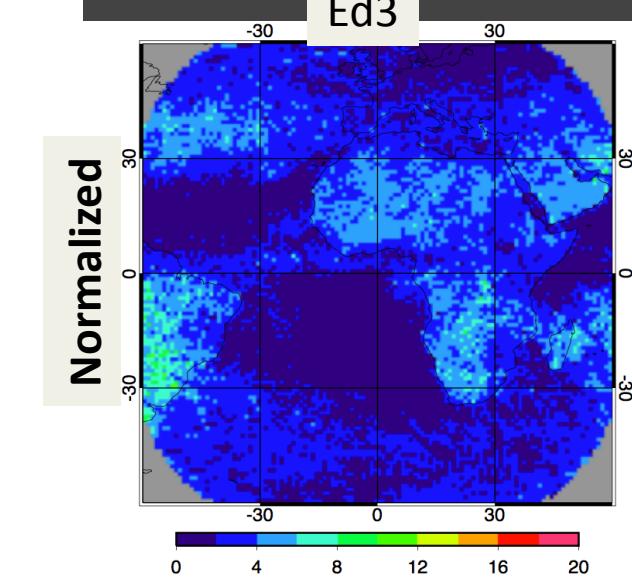


Daily Mean



Monthly hourly Mean

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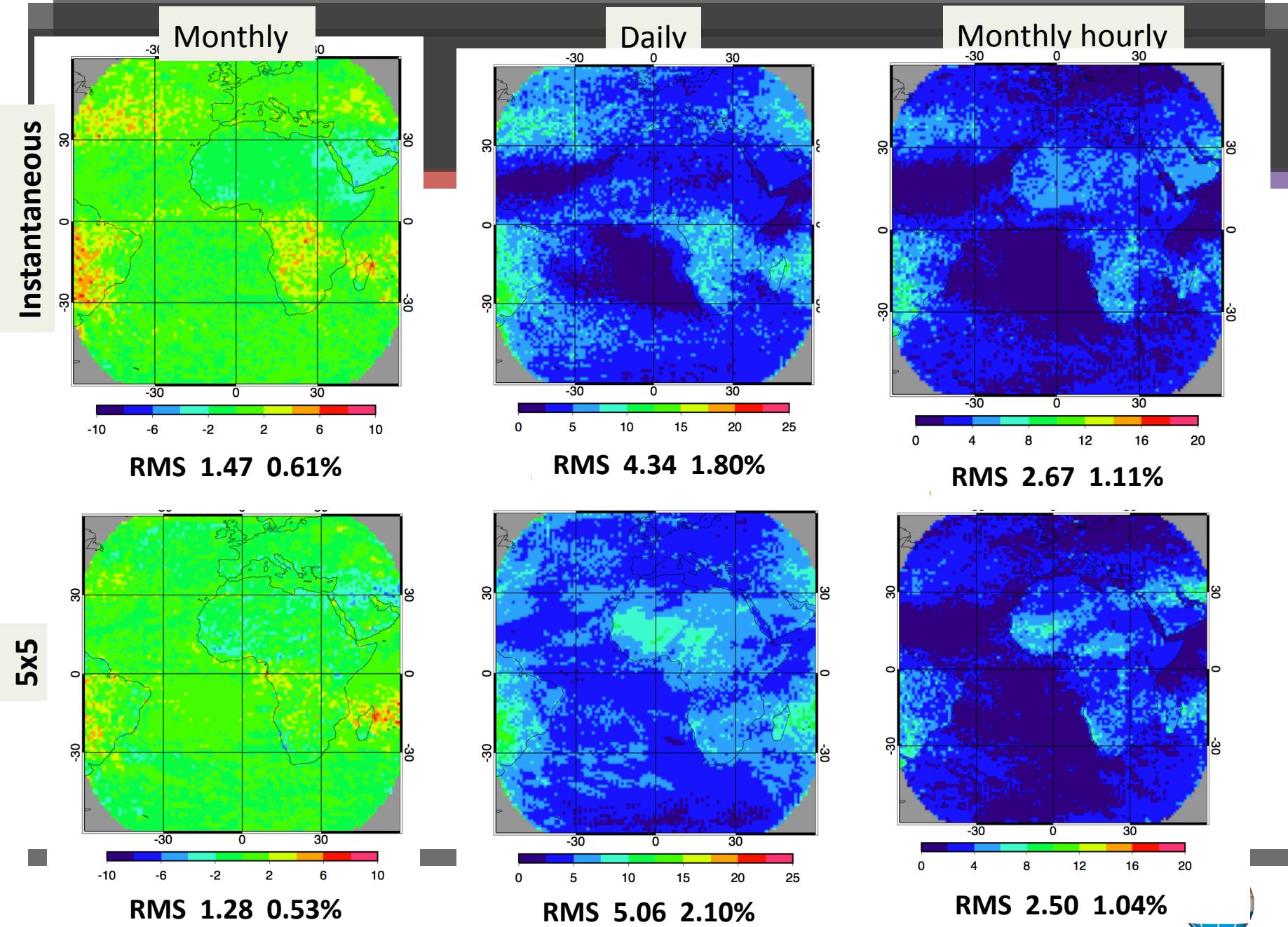
Summary of RMS

		Ed3	1-Step	2-Step
Before Normalization	Monthly Mean	5.78 (2.40%)	2.78 (1.16%)	2.56 (1.06%)
	Daily Mean	7.57 (3.14%)	4.78 (1.98%)	5.86 (2.43%)
	Monthly Hourly	5.98 (2.47%)	3.40 (1.41%)	3.59 (1.49%)
After Normalization	Monthly Mean	1.47 (0.61%)	1.09 (0.45%)	1.36 (0.65%)
	Daily Mean	4.33 (1.80%)	3.84 (1.59%)	4.56 (1.89%)
	Monthly Hourly	2.67 (1.11%)	2.46 (1.02%)	3.17 (1.32%)



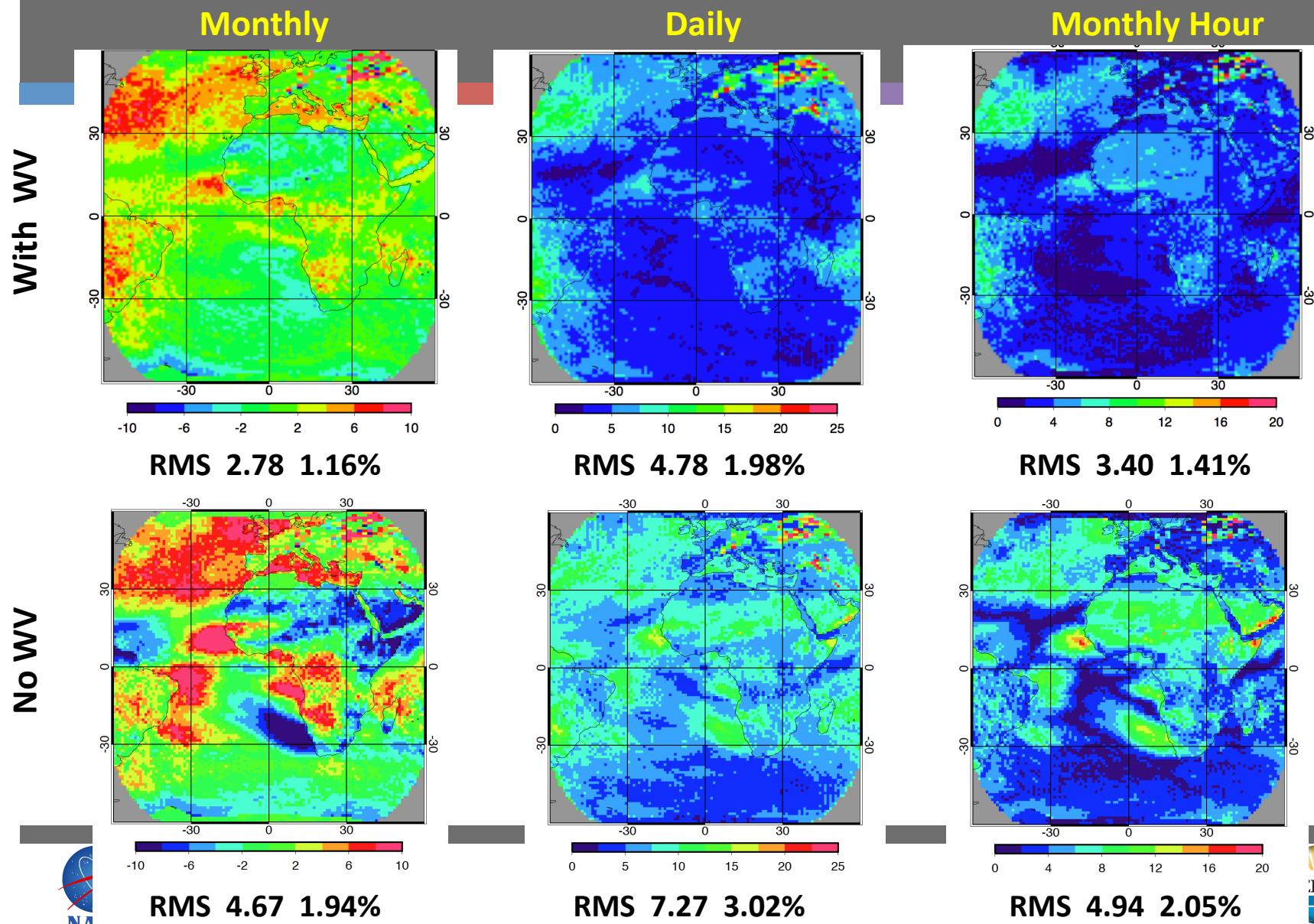
Ed3 Normalization effect

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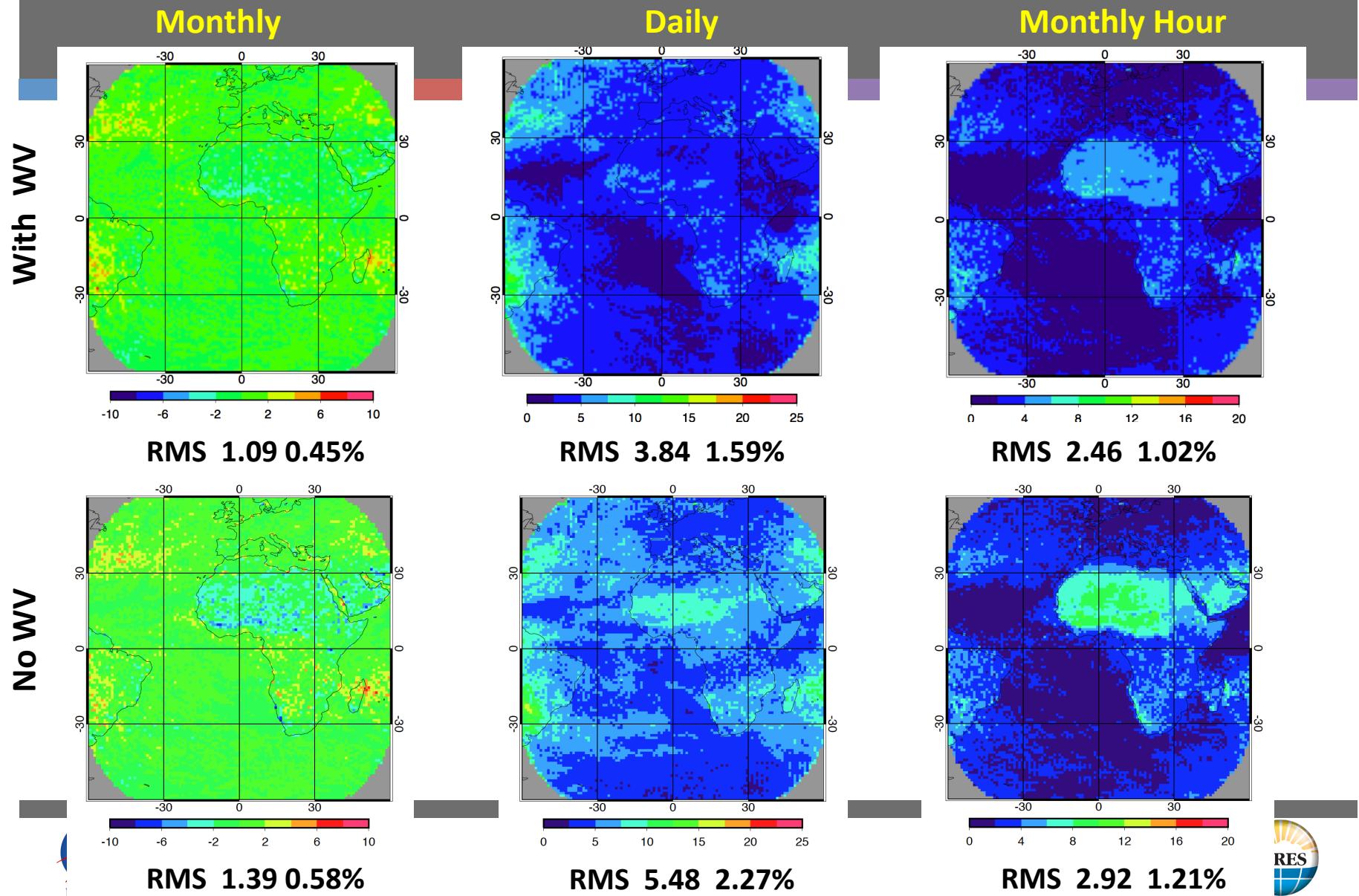
Impact of WV Chan Ed4 1-Step, Before Normalization

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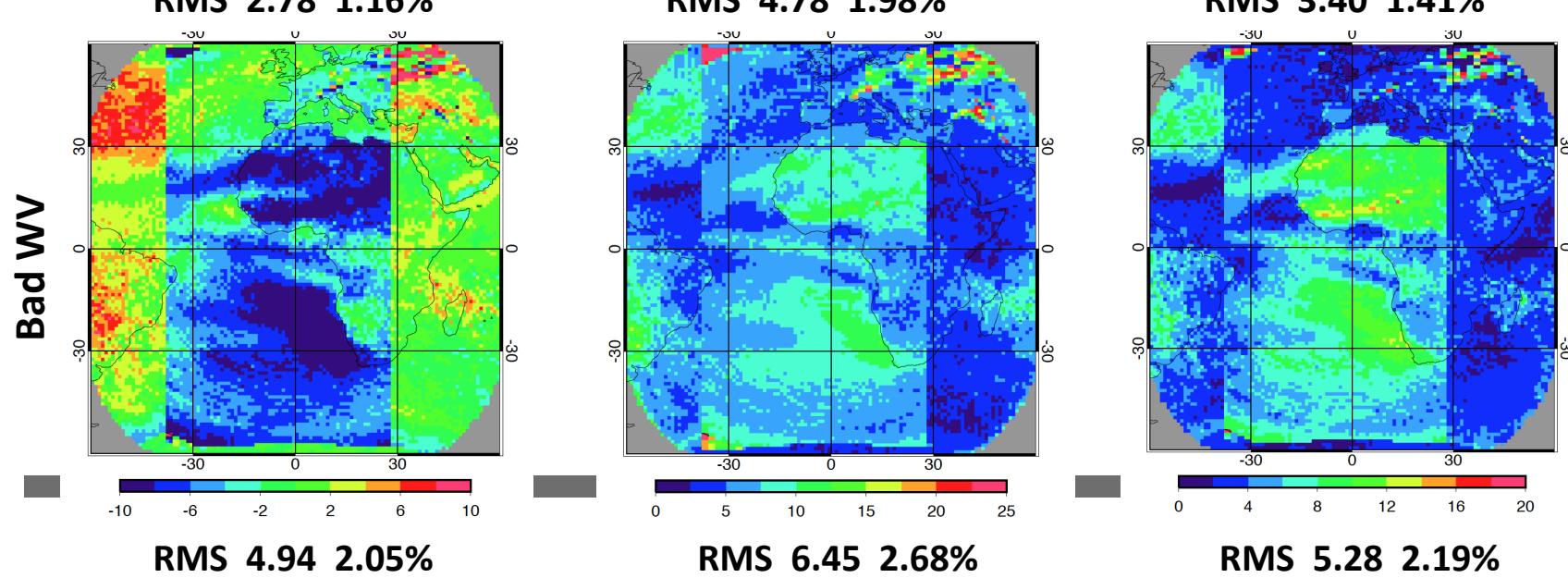
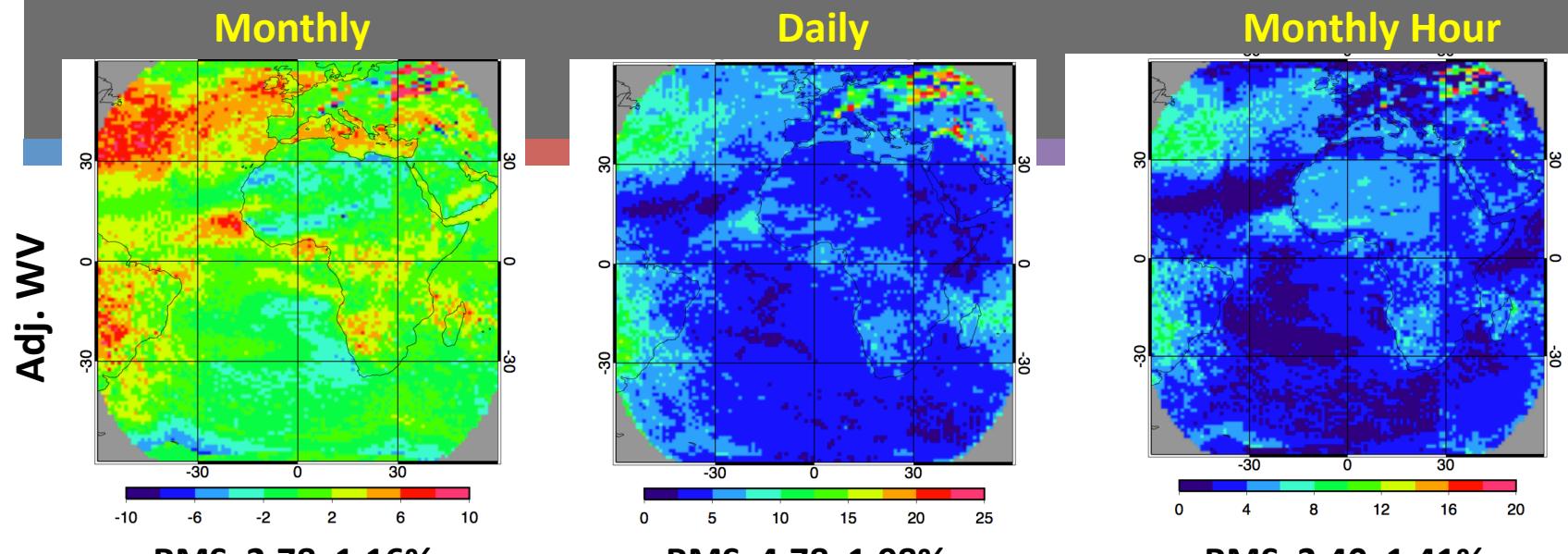
Impact of WV Chan Ed4 1-Step, After Normalization

20

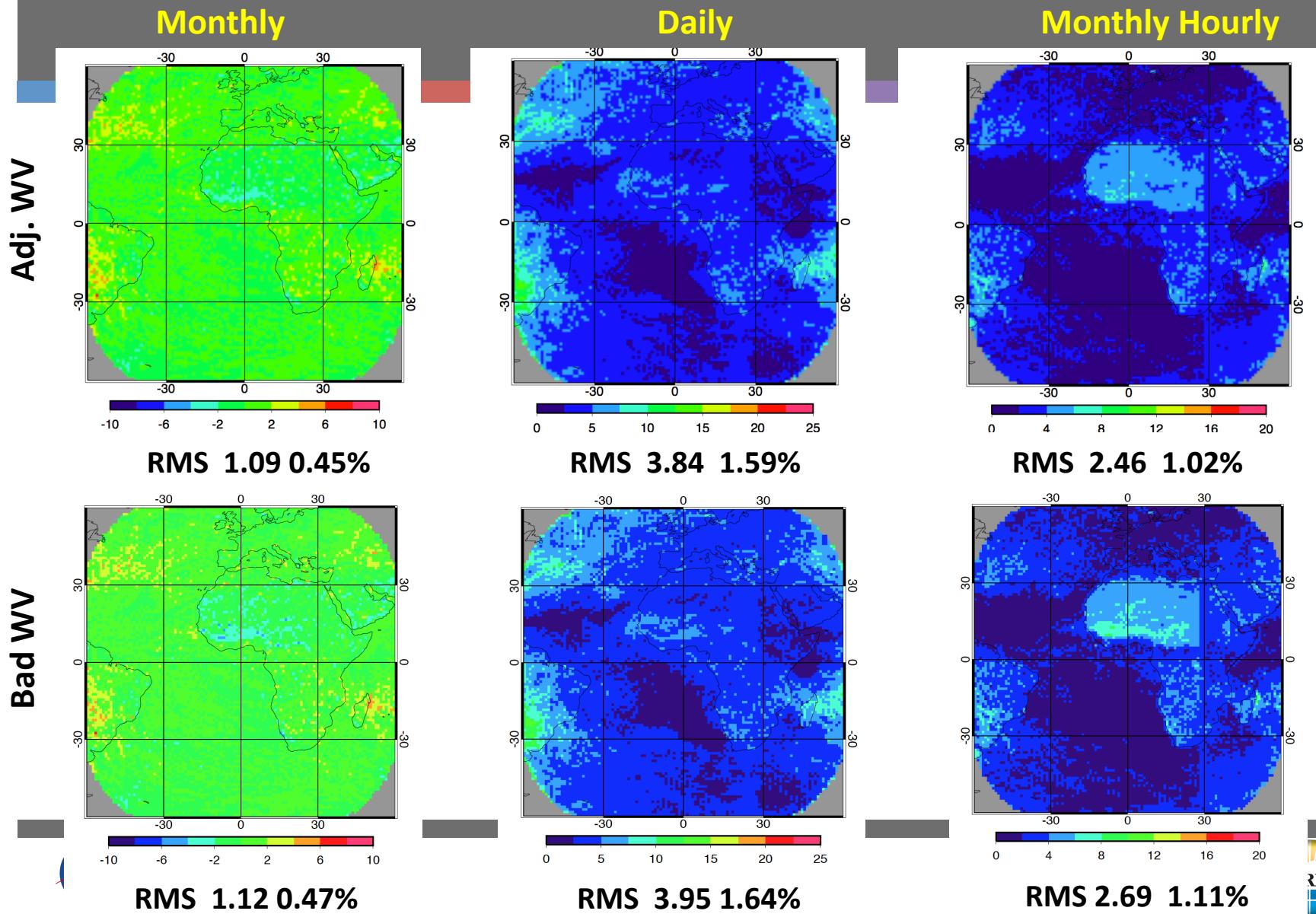


Impact of Unadjusted WV Chan Ed4 1-Step, Before Normalization

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Impact of Unadjusted WV Chan Ed4 1-Step, After Normalization



Summary

- 1-Step, a very simple algorithm, shows consistent improvement over 2-step and Ed3 algorithm. Desert region shows much improvement.
- Normalization reduces RMS greatly. 5x5 normalization is slightly better than instantaneous normalization.
- WV channel is very important for the improvement of LW flux. Unadjusted WV affects fluxes greatly without normalization.
- We need both IR+WV channel and normalization for LW improvement.



Future Work

- Continue to refine the algorithm, especially over regions which show worse results compared with that of the Ed3.
- Validation: check three more seasonal months before delivery: April, July, October.



Thank You!

